USACE Use of Risk Analysis for Flood Risk Management

Objectives

- Background for Flood Damage Reduction Analysis
- Introduce Risk Analysis
  - Why Use Risk Analysis?
  - Hydrology
  - Hydraulics
  - Economics
  - Monte Carlo Approach
- Issues
- Current/Future Activities
- Terminology

ER 11-5-2-100 Planning Guidance Notebook

ER 1105-2-101 Risk Engineer Regulation

EM 1110-2-1619 Risk Engineer Manual

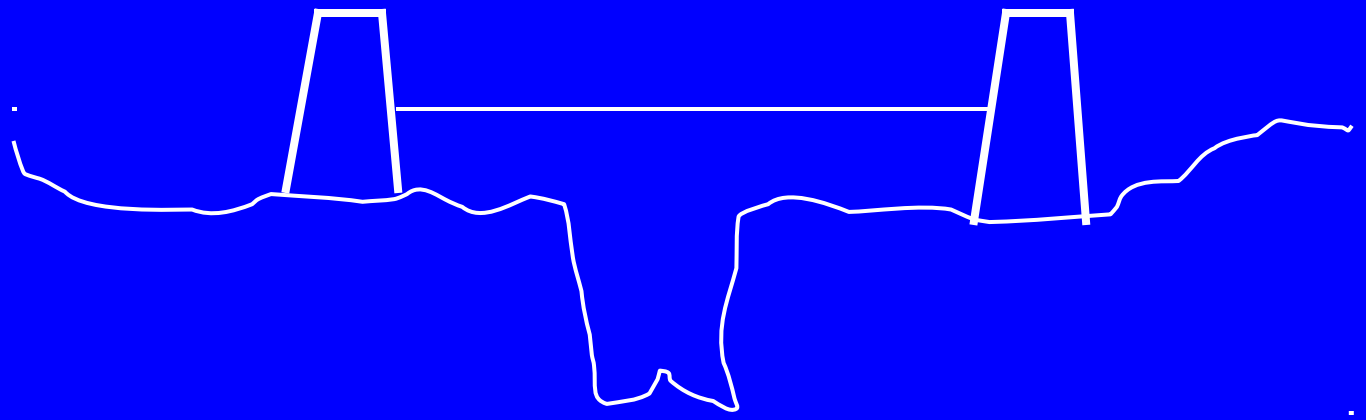
Background/History

- One of the primary Civil Works Missions of the USACE is to provide flood protection;
  - During Flood Episodes
  - Studies and Implements Flood Reduction Measures
- Corp's has reduced flood damage by implementing many structural and nonstructural measures.
- Procedures and Programs;
  - meet changing needs of the country
  - utilize new science & technology

Flood Damage Reduction Analysis

- We need to answer the question “Which proposed flood damage reduction plan is the best from an economic standpoint?”
  - Evaluate the existing condition
  - Analyze alternative damage reduction plans
- Compare plans using Expected Annual Damage (EAD) and damage reduction benefits.
- Since 1996, use risk analysis procedures.

Why Use Risk Analysis?



Situation 1. Flat gradient, flow/stage variability low, long record.

Situation 2. Steep gradient, flow/stage variability high, short record.

Risk analysis explicitly distinguishes between these situations, and better assures consistent treatment of risk associated with project performance.

Risk Analysis

The analysis of flood damage reduction measures and plans using the principles associated with risk and uncertainty.

Considers the uncertainties associated with imperfect/short record lengths, incomplete knowledge, imperfect analysis methods, nature.

Risk = probability of event x probability of exceedance/failure x consequence of exceedance

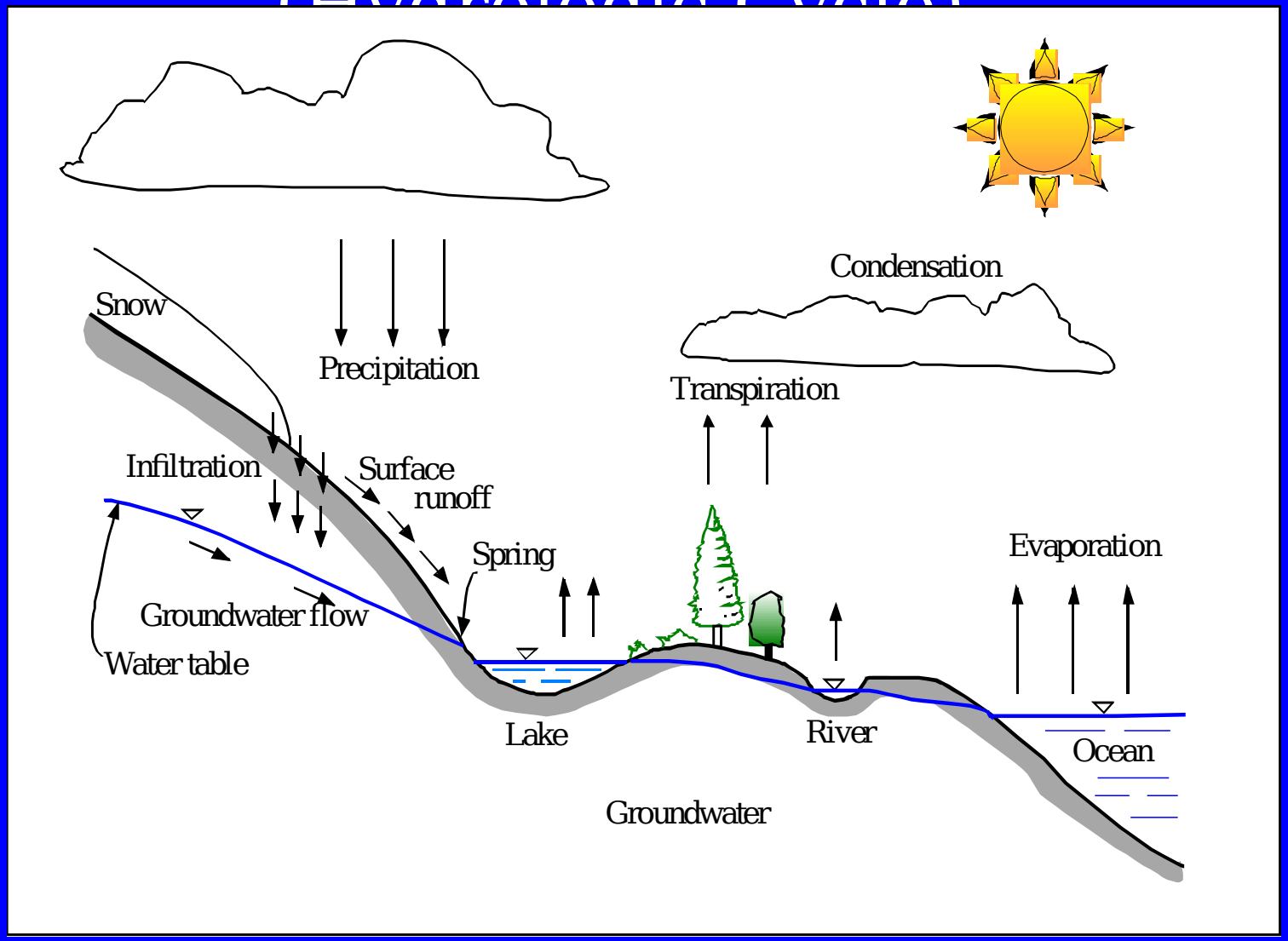
We now consider Loss-of-Life

Risk Analysis

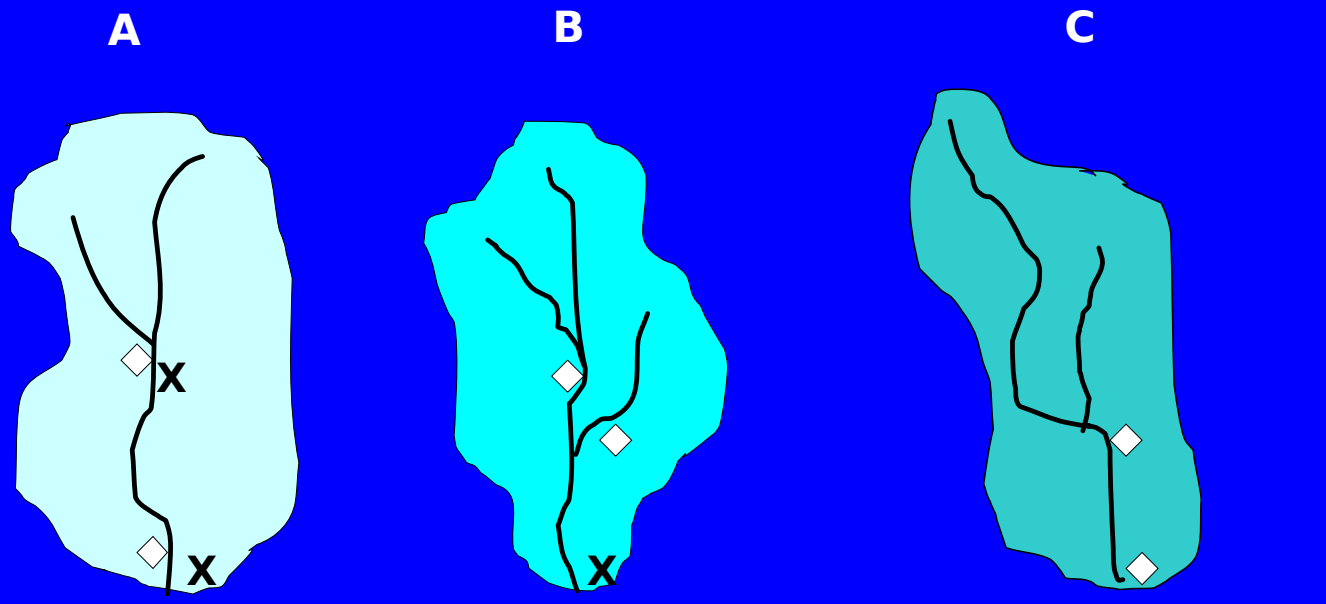
- Perform traditional analysis of hydrology, hydraulics, economics.
- Define uncertainties of discharge-frequency, stage-discharge, and stage damage functions, and geotechnical failure relationships.
- Perform Monte Carlo Analysis to obtain expected values for economics and performance.

Uncertainty in the Runoff Process

(Hydrologic Cycle)



Develop Discharge-Exceedance Probability Curves

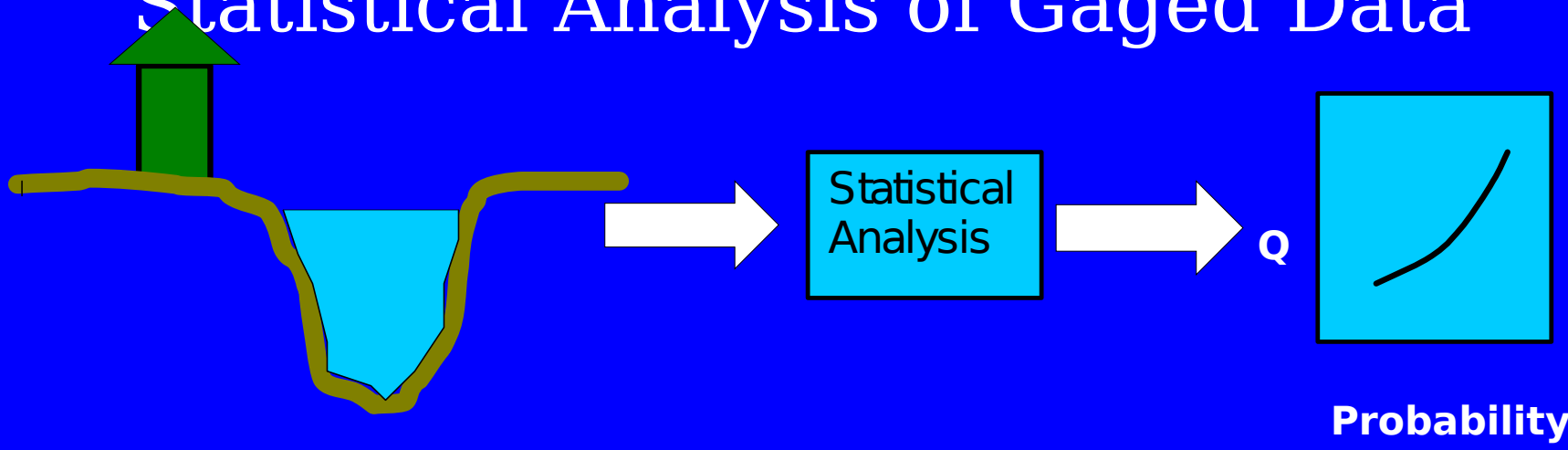


X - Gage Location

◇ - Frequency Curve Needed

Analytical Flow-Frequency Curve

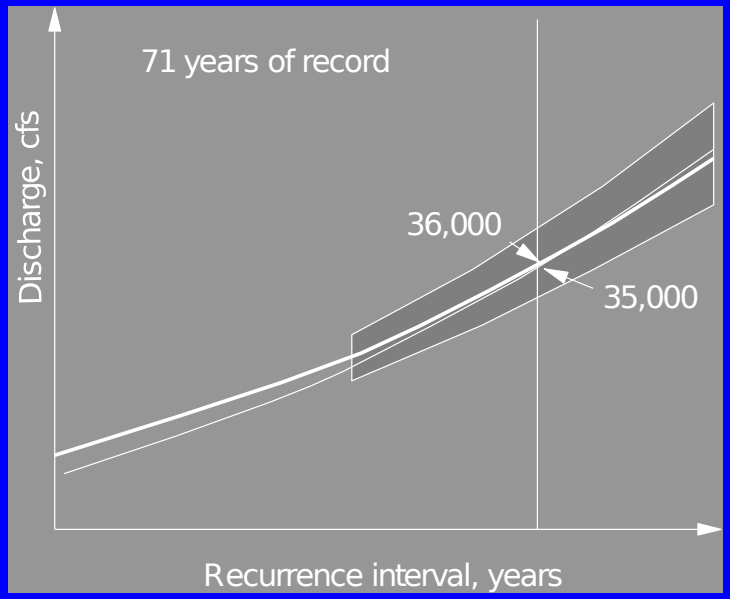
Statistical Analysis of Gaged Data

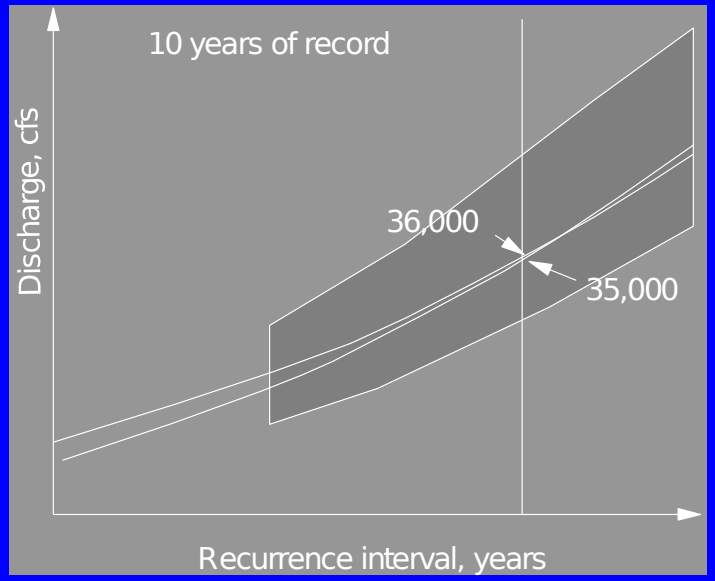


- Apply Bulletin 17B Procedures
  - Log-Pearson III Distribution
    - »Method of analyzing peak flow data
  - Assumptions
    - »Watershed Characteristics Unchanged
    - »Sufficient Record Length

Discharge-Probability Uncertainty

"Length of Record" Determines Confidence



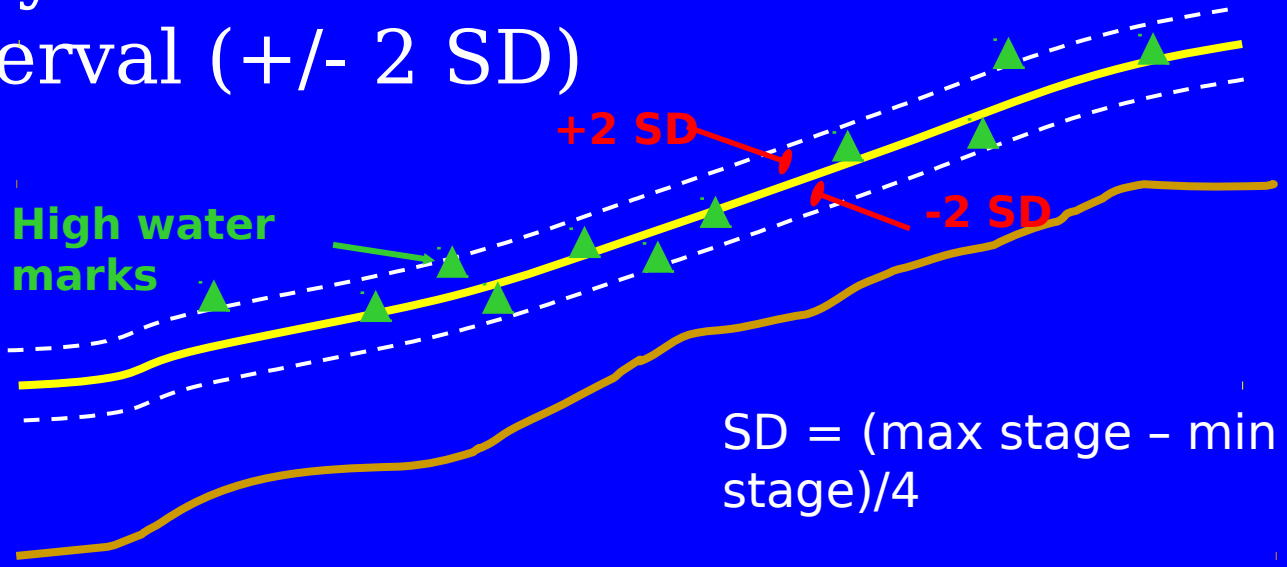


Uncertainty in Stage Estimates

- Some Factors that Cause Uncertainty:
  - Cross section shape, area, and roughness
  - Debris and other obstructions
  - Sediment transport, scour, and deposition
  - Bedforms (changing with depth and temperature)
  - Backwater effects
  - Bridges, culverts, and other hydraulic structures
  - Survey error
  - Measurement error

Sensitivity Analysis and Professional Judgment

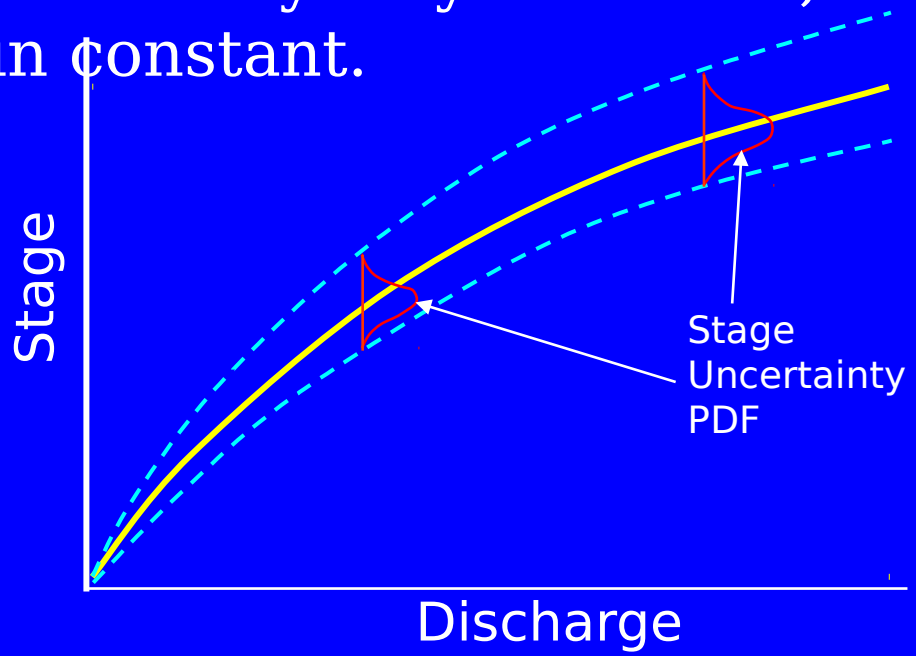
- Calibrate
- Sensitivity analysis of key parameters
- Vary *n* to estimate the 95% confidence interval (+/- 2 SD)



Perform for a range of frequency events

Stage Uncertainty Probability Density Function

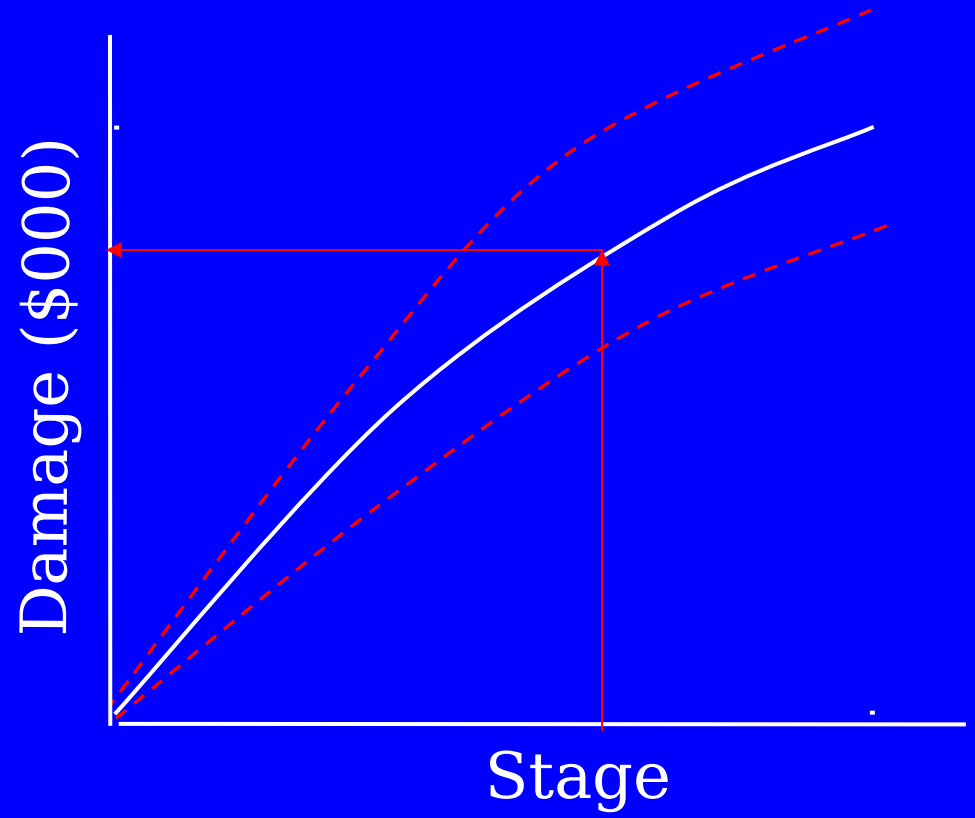
- Uncertainty is zero at zero discharge.
- Uncertainty increases as discharge increase to Bankfull Stage.
- Above Bankfull, Uncertainty may increases, decrease, or remain constant.



Economic Uncertainty

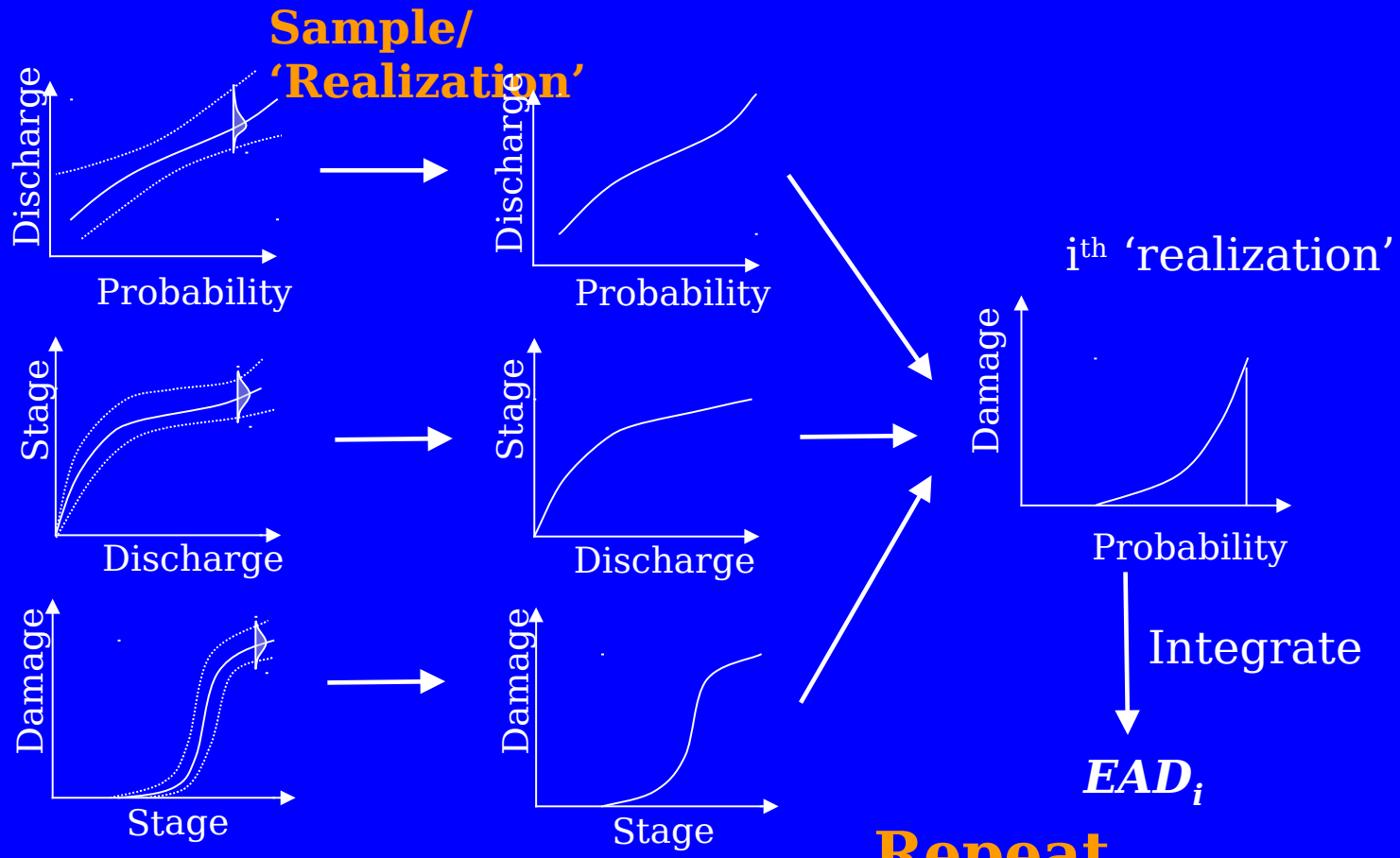
- Most residential and some common commercial damage estimates combine information on:
  - Number of structures by building and construction types
  - Structure values by building type and usage
  - Content values by building type and usage
  - Content-to-Structure ratio
  - First floor elevation of structure
  - Damage as a percent of value for structure and contents for various flood depths
  - Flood depths at damage location corresponding to river stages at a reference location
  - Warning time
  - Flood fighting

Stage – Damage with Uncertainty



A summary statement of the direct economic cost of floodwater inundation for a specified stream reach

Calculating EAD using Monte Carlo



Repeat 'realizations' until stable statistics

Risk Analysis Results

- Economic
  - Expected Annual Damage
  - Expected Annual Damage Reduced
  - Distribution of Expected Annual Damage (damage reduced)
  - Equivalent Annual Damage
- Performance
  - Annual Exceedance Probability
  - Expected Long-term (10, 30, 50 years) Exceedance probability
  - Conditional Non-Exceedance Probability (Assurance)

Issues

- Continued use of deterministic approaches
  - Geotechnical
  - Mechanical
  - Electrical
  - Interior Drainage
- Definition of extreme events and their uncertainty
- Understanding
  - Guidance/Training/Communication
- Lack of comprehensive methods/software
  - Systems approach
  - Other disciplines

Current/Future Activities

- Engineering Technical Letter 1110-2-570, Levee System Certification
- Dam and Levee Safety Programs
- FDA Version 3.0 Software